DOCUMENT RESUME

ED 301 469 SE 050 220

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TITLE A Commentary on Gender Differences.
INSTITUTION Manitoba Dept. of Education, Winnipeg. Planning and Research Branch.
REPORT NO ISBN-0-7711-0641-6; RR-86-07
PUB DATE Dec 86
NOTE 13p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Literacy; Elementary Secondary Education; *Females; Foreign Countries; Mathematics Education; Science Education; *Science Instruction; Sex Bias; *Sex Differences; *Teaching Methods
IDENTIFIERS *Manitoba

ABSTRACT

The development of knowledge and skills in the areas of mathematics, science, and computers is considered to be important for all students, both males and females. These subjects are prerequisites for many postsecondary education programs. Some of the most highly paid sectors of the labor market are those which require math, science, and computer knowledge. The importance of these fields in a person's everyday life should not be underestimated. Women tend to be under-represented in these fields. This paper provides an overview of this issue and a description of what is known about the situation in the province of Manitoba. Discussions in this report center around enrollment, achievement, and social factors. A list of six suggestions to improve the situation are included. (CW)

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ED301469

RESEARCH

A Commentary on Gender Differences.

A REPORT OF THE
PLANNING AND RESEARCH BRANCH
MANITOBA EDUCATION

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Manitoba Education

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December, 1986

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370.19345
Morrow, Dallas.
A commentary on gender differences.

(Manitoba. Manitoba Education. Planning and Research. Research ; 86-07)

Also known as: A commentary on gender differences in math, science, and computer-related courses.
ISBN 0-7711-0641-6

1. Sex differences in education. 2. Women in science. 3. Women in science--Manitoba. 4. Women in mathematics. 5. Women in mathematics--Manitoba. I. Goertzen, Sandi. II. Manitoba. Manitoba Education. Planning and Research. III. Title. IV. Title: A commentary on gender differences in math, science, and computer-related courses. V. Series.

SUMMARY

The development of knowledge and skills in the areas of mathematics, science, and computers is considered to be important for all students, both males and females. This paper provides an overview of the issue of gender differences in mathematics, science, and computer-related courses, describes what is known about the Manitoba situation, and puts forth some suggestions for addressing this concern. The following highlights reflect the contents of the paper.

- When achievement differences are found, they are usually small and favour males. As well, females show an achievement advantage on some measures.

- The relationship between gender and achievement is complex. One certainly cannot predict achievement in mathematics, science, and computer-related courses on the basis of gender.

- Manitoba female enrollments overall in mathematics, science, and computer-related courses are slightly below male enrollments (48% compared to 52%). However, the most significant differences appear within subject areas. For example, Biology class enrollments are 56% female while Physics class enrollments are only 37% female. Similarly, females comprise 29% of Computer Science enrollments, 41% of Computer Studies and Computer Awareness, and 54% of Data Processing enrollments.

- A variety of social factors are thought to influence female students in these subjects. The concept of "stereotyping" is central to these influences.

- Course content, student attitudes, experiences outside of the classroom, parental and teacher expectations, school practices, the media, and student/teacher interaction are some of the interrelated factors which together appear to have a profound effect on females and their mathematics, science, and computer experiences.

- Suggestions for new and continued actions which can contribute to the elimination of this gender disparity include among others: increase the sensitivity of teachers to this concern, improve career counselling, revise course content and encourage greater female participation.

RÉSUMÉ

On considère qu'il est important que tous les élèves, autant les filles que les garçons, acquièrent des connaissances et des compétences dans le domaine des mathématiques, des sciences et des ordinateurs. Le présent document donne un aperçu des différences entre les filles et les garçons dans ces domaines. Il décrit également les données dont on dispose sur la situation au Manitoba et suggère quelques idées pour s'attaquer à ce problème. Les observations suivantes résument l'essentiel du document:

- Lorsqu'il existe des différences entre les niveaux de réussite des deux sexes, celles-ci sont généralement négligeables, par contre, même si négligables elles sont à l'avantage des garçons. Cependant, les filles réussissent mieux que les garçons dans certains domaines.

- La question du lien entre le sexe et la réussite scolaire est compliquée. On ne peut certainement pas prévoir la réussite en mathématiques, en sciences et en cours liés à l'informatique d'après le sexe de l'élève.

- Le nombre de filles inscrites en mathématiques, en sciences et en cours liés à l'informatique est un peu moins élevé que celui des garçons (48% par rapport à 52%). Mais à l'intérieur de ces domaines, on constate des différences importantes. Par exemple, les filles représentent 56% de l'effectif dans les cours de biologie mais seulement 37% dans les cours de physique. De la même manière, les filles représentent 29% de l'effectif dans les cours d'ordinatique, 41% dans les études d'informatique et les cours d'initiation à l'informatique et 54% dans les cours de traitement de données.

- On croit que toute une gamme de facteurs sociaux influent sur les filles dans ces domaines, notamment les "stéréotypes".

- Le contenu des cours, les attitudes des autres élèves, les expériences extrascolaires, les attentes des parents et des professeurs, les pratiques de l'école, les médias, et l'interaction entre l'élève et le professeur figurent parmi les facteurs interdépendants qui, pris de façon globale, semblent avoir un effet profond sur les filles et leurs expériences dans le domaine des mathématiques, des sciences et de l'informatique.

- Pour tenter d'éliminer ces différences, on propose d'entamer ou de poursuivre, entre autres, les démarches suivantes: sensibiliser davantage les professeurs à ce problème, améliorer l'orientation professionnelle, réviser le contenu des cours et encourager la participation féminine.

A COMMENTARY ON GENDER DIFFERENCES IN MATH, SCIENCE, AND COMPUTER-RELATED COURSES

Introduction

The intent of public schools is to provide children with the opportunity to develop the knowledge and skills they will require in adult life. It has become increasingly evident that the areas of math, science, and computers are vital. These subjects are prerequisites for many post-secondary education programs. Some of the most highly paid sectors of the labour market are those which require math, science, or computer knowledge. As well, the importance of these fields of study throughout our everyday lives should not be underestimated.

Women tend to be under-represented at universities and in the labour market in areas involving math, science, and computers. What role have the public schools played in creating and maintaining this gender disparity? What role can they play in alleviating it? This paper will address these questions, providing an overview of the issue and a description of what is known about the Manitoba situation.

Much has been written about gender differences in education, both in Canada and the United States. Math and science have been extensively examined. Computers, being comparatively new, have generated much recent interest. Efforts to assess the magnitude of gender differences in these subjects have centered upon measures of achievement and enrollment.

Achievement and Enrollment

Interpretation of the evidence on achievement differences is extremely difficult. Results vary depending on the subject areas and types of questions tested. For example, a larger male advantage can be seen in physics compared to biology and items testing specific content differ from items which test process skills. Some studies fail to detect any gender differences and others report a female advantage on certain measures. Methodological problems such as failing to control for the number of math courses students have previously taken, can distort the results.

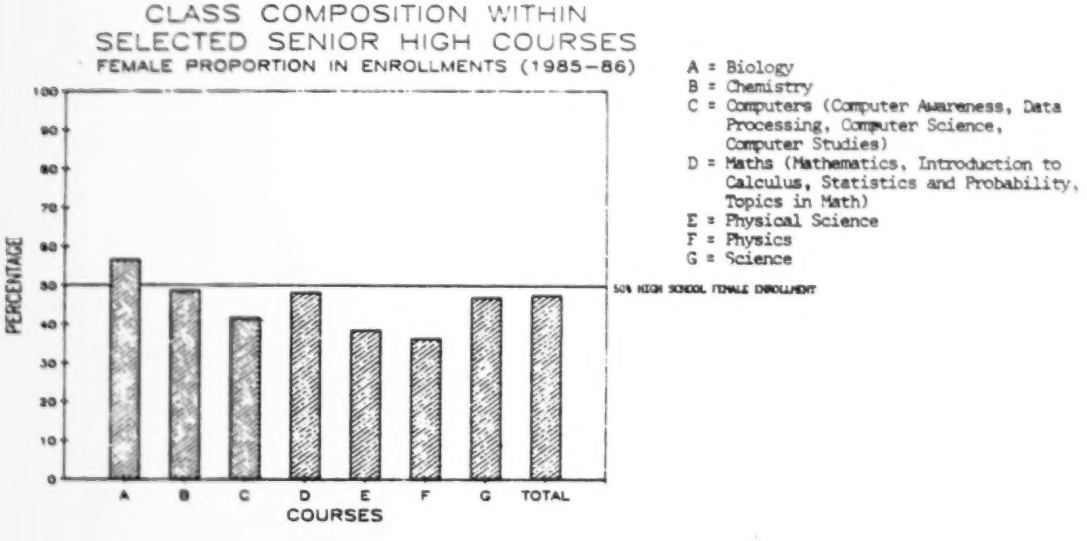
In order to gain some insight into Manitoba's situation regarding gender differences in achievement the provincial assessments can be examined. The Manitoba Science Assessment Program 1980 (Grades 3,6,9, and 12) and the Manitoba Mathematics Assessment Program 1981 (Grades 5,8, and 11) both investigated the possibility of gender differences in achievement. In mathematics at the Grade 12 level, males showed a clear advantage on the course specific tests. However, the overall mathematics results were mixed. Of all subtests which evidenced statistically significant gender differences, males had the advantage in eleven and females in ten. In the science assessment, males tended to outperform females on knowledge, comprehension and application in earth and space and physical science. They had slightly better performance on higher cognitive level thinking and on the processes of science. At the Grade 11 level, females had better performance on the application of life science and on the nature of science items. In the Manitoba assessments, as in studies elsewhere, when gender differences are found they tend to favour males. However, the results would seem to reflect a complex relationship between gender and achievement.

A key question concerning gender and achievement is whether or not a biological factor (hormonal or genetic) may be the underlying cause of the gender differences in achievement levels. This has important implications for the possibility of intervention. Male proficiency in spatial abilities, purportedly biologically based, has been put forth as an explanation for higher math/science achievement. However, there is mixed evidence that spatial abilities are biologically based. As well, it is not clear to what degree spatial abilities are related to math/science learning. If we assume that spatial abilities are an important factor, most measures of spatial abilities show only a small male advantage. In fact, although gender differences appear with some consistency on various assessments of cognitive performance, they are also consistently small and account for only a small portion of the population variance. The essential point is that gender appears to account for such a small part of individual differences in achievement that one conclusion is clear. Individual achievement in math, science, and computer-related courses certainly cannot be predicted on the basis of gender.

Enrollment differences for males and females in math, science, and computer-related courses are well documented in the literature. Females have been less likely to enroll in math and science courses in high school, although this has improved in recent years. Studies reveal important

enrollment variations within subject areas. For example, female enrollment tends to be much less in physics than in the biological sciences. In the area of computers, boys tend to dominate participation in programming activities, while there is usually no distinction between sexes in word processing.

An analysis of Manitoba high school class compositions reveals enrollment disparities in this province. The situation, however, is better than what might be anticipated. Overall, male/female enrollment differences in math, science, and computer-related courses are relatively small. As shown by the "total" bar on the following graph, approximately 48% of the students in the selected high school classes (math, science, and computers) were female, compared with the overall 50% high school female representation.



Female enrollment in general science courses is only slightly below male enrollment, however, in the more specialized courses differences become more apparent. Female enrollment ranges from a high of 56% in biology to a low of 37% in physics and physical sciences. These results reflect the same general enrollment patterns found in the literature.

Greater gender differences are also evident in specialized math courses. The "math" bar on the graph indicates that 48% of students in all high school math classes are female. However, further analysis reveals that in the specialized Grade 12 math classes (Introduction to Calculus, Statistics and Probability, Topics in Math) female enrollment falls to 36%.

In computer-related courses, enrollment figures indicate an advantage in favour of males. However, as was the case with math and science, differences exist within computer disciplines. Female enrollment in Computer Awareness and Computer Studies is approximately 41% while enrollment in Computer Science is only 29% female. Data Processing, which is a business education course, has a majority of females enrolled (54%).

The continuing and pervasive adult female disadvantage in math, science and computer knowledge defies a simple explanation. Can we say that this exists because females are just not as able as males to achieve in these areas? Are the high school enrollment disparities in these courses large enough to account for the adult disadvantage? Or, perhaps, are enrollment and achievement differences symptoms of some other influencing factors?

Social Factors

The research on gender differences has addressed a wide variety of social factors such as peer influence, student/teacher interaction and student attitudes which are thought to influence female students in the areas of math, science, and computers. The difficulty with discussing these factors is that they are not easily quantifiable, their effects may be subtle and indirect, and they are seldom examined apart from their influence on enrollment and achievement. This does not mean that they should be dismissed. Further research, particularly qualitative research, would be useful in establishing a better understanding of the variety of influences on female students. Evidence from research which has been conducted points to many interrelated factors which together appear to have a profound effect on females and their math, science, and computer experiences.

Central to these influences on female students is the concept of "stereotyping". Math, science, and computers are all perceived to some degree as being "male". Boys are more likely than girls to be exposed to math/science principles outside of school and to have outside experience with computers. Since new information is more easily learnt if it is linked to existing information or past experience, this confers a distinct advantage on boys. Course content is related to this concern in that it is often unintentionally geared to the kinds of experiences boys are more likely to bring with them to the classroom. The use of examples can be biased toward boys such as using football scores in a mathematical problem or the workings of gears in science. One effect of this tendency toward a male slant is to make the subject area more interesting for boys than girls. Boys often exhibit more positive attitudes toward

math, science, and computers. Interest in these areas is likely to increase the amount of outside school time boys devote to related activities compared to girls, thus exacerbating the problem.

The major concern about biased course content is that it can relay the subtle message that math, science, or computers are not appropriate or relevant for girls. Students begin to make career decisions at a time in their lives when peer pressure can be at its greatest. If girls feel that math, science, or computers are predominantly "male", their need to assert their femininity may steer them away from interest and success in these areas. This is why it is vital that all students, both boys and girls, perceive math, science, and computer careers as something that men and women do.

Many factors can contribute to the perception that math, science, and computers are inappropriate or unimportant for women. In direct opposition to the changing realities of Canadian society, many young women expect to be financially dependent in their adult lives and, as such, are less concerned about obtaining a well paying career in a field which may involve math, science, or computers. The media, which typically portrays scientists as men is another factor. An examination of advertisements for computers reveals that they depict few females using this technology. Parents may also be unintentionally allowing stereotypes to limit career options for their daughters by lowering their expectations for success in math, science, and computer-related courses.

Within the schools, two areas in addition to course content stand out as being of concern with respect to their potential contribution to gender differences. These are school practices and teacher/student interaction.

School practices may create an inequitable learning environment for students. When resources are scarce students must share science and computer equipment. Some schools institute irrelevant prerequisites to determine access to the equipment, such as giving computer time to students who finish their assignments first or who have the highest math scores. In the typical classroom situation where students share science equipment, observers often report that girls get fewer opportunities to perform the "hands-on" activities. Another school practice which is considered to be detrimental to girls is the tendency of schools to incorporate computers into the math department. Thus the new area of computers, which in the outside world relates to a variety of

disciplines including math, music, literature, and business assumes the male stereotype associated with mathematics. The pattern of sex differences in computer usage appears to be related to how computer instruction is organized and supported in the school.

Teacher/student interaction is another aspect of schools which has been examined for its relationship to gender differences. Differential treatment of boys and girls by their teachers is a concern, and while this is nearly always unintentional it does exist. Boys tend to receive more overall attention than girls, particularly corrective and instructional attention. Teachers, like parents, may unconsciously lower their expectations for girls in math, science, and computers. Low achieving boys are more likely to be referred for remedial assistance than are low achieving girls. Teachers perceptions of their students' interests and abilities are crucial and these perceptions are not always accurate. Mistakenly thinking that girls are less interested in math or science can have disastrous results.

When differential treatment of male and female students has been observed, the teachers involved are almost always unaware of their behavior until it is pointed out. This hidden nature of teacher/student interaction is what makes it one of the most important areas to address.

What Can Be Done In Schools?

Gender disparities are a product of our society as a whole and we cannot look to schools to eliminate them alone. However, public schools do exert an important influence on young people. For this reason, they have a great deal of potential to contribute to the reduction of gender differences in math, science, and computers. A variety of suggestions have been made about how this can be done and efforts are currently underway by Manitoba educators in many of these areas. The following are some suggestions for new and continued action. While these suggestions particularly relate to the high schools, stereotyping begins much earlier. Efforts need not, and should not, solely be directed at the high schools.

1. Educate teachers - improve the sensitivity of teachers to the subtle and unconscious influences found in curriculum and instruction. Invite equity specialists into the classroom in order to observe teachers and provide them with feedback. Circulate literature and have inservices which inform teachers of the problem and offer suggestions for improvement.

2. Improve career counselling - all students must be informed of the importance and relevance of these subjects to their future. Inform students of the consequences of "dropping" these subjects. Invite both men and women in related careers to speak to students about their occupations. Openly discuss the male stereotype of these subjects in order to help all students overcome it.

3. Encourage female participation - do not let boys dominate discussions or activities. Plan for equal participation by all students. Structure science and computer labs so all students actively work with the instruments and equipment. Computer labs could have days designated as "boys only" or "girls only" although care must be taken to ensure that standards are comparable.

4. Broaden the use of computers - avoid incorporating computers into the math department. Rather, utilize them in a variety of areas such as language, music, math, bookkeeping, graphics, etc. Emphasize the computer as a universal tool with a variety of uses. Examine prerequisites carefully, in order to determine whether they are relevant, equitable, and necessary.

5. Continually revise course content - all biased material should be removed from the curriculum. Use textbooks that portray both males and females in active roles. Efforts should be made to use materials and examples that are of interest to both males and females.

6. Demand equal standards - demand the same quality of work from both males and females. Do not lower standards or expectations for girls. Most importantly, treat students as individuals with different interests and abilities.